Summary of acoustic work to assess the biomass of aggregated chokka squid on its inshore spawning grounds on the south-east coast of South Africa in the season closed for fishing

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Recent attempts to estimate the biomass of aggregated squid on the inshore fishing ground by acoustic surveys in November, when the fishery is closed for conservation purposes are described. Pilot surveys of aggregations, covering part of the fishing ground, were conducted in 2019 and 2020, followed by a multi-phase survey of the entire ground within the 50 m depth contour by two vessels in 2021. A further full-scale survey, following the methods employed in 2021 has very recently been completed (results not yet available). The survey grids for the first two phases of the 2021 survey are shown in Fig. 1, demonstrating the extent of the cover and the exceptionally close spacing of the lines (0. 5 NM for the two phases combined). The survey, conducted exclusively by day, followed standard echo-integration practice (e.g. Simmonds and MacLennan 2006), including high-precision sphere-calibration of both echo-sounders during the course of the survey. Targets were identified as squid from a combination of their morphology, position in the water column, volume density and, at times, the target strength of clearly-identifiable individuals. Biomass estimates were obtained from the measured acoustic back-scatter along the transects using the following target strength/length relationship for *L. reynaudii* developed by Soule and Hampton (2010) from both *in situ* and *ex situ* experiments between 2001 and 2007.

$$TS = 15.99 \, Log \, ML - 65.80 \quad ,$$

where ML is the mantle length in cm. The expression was applied to a pooled length distribution derived from samples taken from catches by two squid jig commercial vessels engaged to work with the research vessels. Sampling CVs were estimated from the variation in density estimates between transects using an expression of Jolly and Hampton (1990) applicable to randomly-spaced transects of unequal length, relying on random variations in transect spacing and in the distribution of the squid to satisfy the randomisation requirement.

The biomass estimates from the survey, together with the corresponding sampling CVs were made for three degrees of certainty in target identification, which was the major source of uncertainty. The estimates are shown in Table 1, which also shows corresponding estimates from the two previous (smaller scale) surveys in 2019 and 2020.

Year	Vessel	Area	Biomass (tonnes) and CV			
			A Category	B Category	C Category	All Categories
2019	*Ellen Khuzwayo*	Cape Recife – Aasvogels Bult	844.5 (0.27)	-	-	844.5 (0.27)
2020	*Abyss*	Maitlands - Cape Seal	221.5 (0.27)	140.8 (0.19)	-	362.3 (0.18)
2021	*Ellen Khuzwayo*	Storms R. – Port Alfred (30 – 50 m)	231.5 (0.51)	322.7 (0.17)	864.6 (0.15)	1 419.1 (0.13)
	Abyss	Storms R. – Port Alfred (<30 m) *	112 (1.00)	260.6 (0.27)	573.7 (0.25)	946.4 (0.20)
	Ellen Khuzwayo + Abyss	Storms R. – Port Alfred (<15 – 50 m)	343.5 (0.47)	583.3 (0.15)	1 438.3 (0.13)	2 365 (0.09)

*Excluding Algoa Bay

Table 1: Biomass and sampling CV estimates (in parenthesis) from all surveys for A - Category targets in all years, A and B - Category targets in 2020 and 2021 and C- Category targets as well in 2021. From data in Soule and Hampton (2020, 2021 and 2022). The A-category targets were regarded as definitely squid, the B-Category targets as probably squid, and the C- Category targets as possibly squid.

The 2021 estimates range from 343 tonnes (CV: 47%) for targets conclusively identified as aggregations of spawning squid from previous knowledge of their sound-scattering characteristics, to 2 365 tonnes (CV: 9%) if all targets which could possibly have been squid were included. From these results an estimate of 635 tonnes with a sampling CV of 20 % (obtained by adding half the B-Category biomass to the A-category estimate, which minimises the maximum error incurred by including B-category targets) was proposed as the most reasonable from the survey. This estimate was considered plausible judged by commercial catches in the two months following the survey, which totalled approximately 400 tonnes.

We conclude that aggregations of *L. reynaudii* can be assessed acoustically by day in the November closed fishing season over the entire inshore fishing ground using standard echo-sounding techniques. Because of the relatively small area, exceptionally fine grids, with some repetition in key areas, squid biomass estimates can be realised in the time available, leading to acceptably low sampling CVs. Due to the long history of target strength studies on *L. reynaudii* and its suitability as a subject for *in situ* target strength estimation, target strength uncertainty is somewhat less of a problem in these surveys than is usual in acoustic surveys of fish stocks, leading to greater confidence in absolute estimates than is commonly the case. It has also enabled target strength *per se* to be used to some extent as an identification tool - a novel approach.

To develop the methods pioneered here into a reliable tool useful in managing the fishery will require a) building up of a time series of acoustic estimates in the closed season, closely following the methods employed in the 2021 survey, b) the improvement of target-identification methods (particularly for less aggregated targets), and c) the broadening of understanding of the dynamics of the population at other times of the year, in which formal integration of environmental sampling into routine surveys will be key. All estimates should be compared as far as possible against commercial catches in the area following the survey as a form of validation. In addition, error modelling, for example by Monte Carlo simulation techniques, with uncertainty in target identification, target strength, calibration and other sources of error as inputs, should be carried out to quantify the effect of the major source of error in both absolute and relative terms.

References

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Fig. 1: Grids worked by *Ellen Khuzwayo* (top) and *Abyss* (bottom) in Phases 1 and 2 of the 2021 survey.